

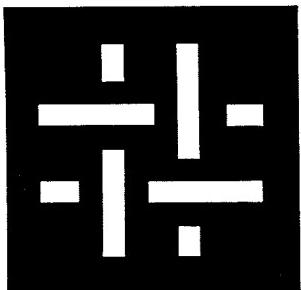
# **WAIS Server**

# **WAIS Workstation**

# **WAIS Forwarder**

**for UNIX**

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*WAIS Inc*

Technical Description  
Release 1.1

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*"Millions of people already use the Internet. WAIS is an important tool helping people navigate through the vast oceans of information of the net, and WAIS Inc is an important pioneer in building the tools which open new information markets."*

Mitchell Kapor, chairman of the Electronic Frontier Foundation  
and founder of Lotus Development Corporation

# 1

# Introduction

## What is WAIS?

WAIS™ (Wide Area Information Servers™) is a network publishing system designed to help users find information over a computer network by simply asking questions. The questions may be expressed in natural language or boolean syntax, and the information sources may be local or remote. WAIS software allows users to search for and retrieve documents from information sources all over the world.

As organizations become flatter and more geographically dispersed, the WAIS network publishing system offers an efficient method for accessing information electronically over interconnected local and wide-area networks, thereby greatly reducing printing and distribution time and expenses.

## The WAIS Architecture

The WAIS software architecture has four main components: the client, the server, the database, and the protocol, as shown in Figure 1. The WAIS client is a user-interface program that sends search and retrieval requests to local or remote servers. Clients are available for most popular desktop environments. The WAIS server is a program that services client requests. Servers are available on a variety of UNIX platforms. The server generally runs on a machine containing one or more information sources, or WAIS databases. The WAIS protocol is used to connect WAIS clients and servers and is based on the NISO Z39.50 Information Retrieval Service and Protocol Standard.

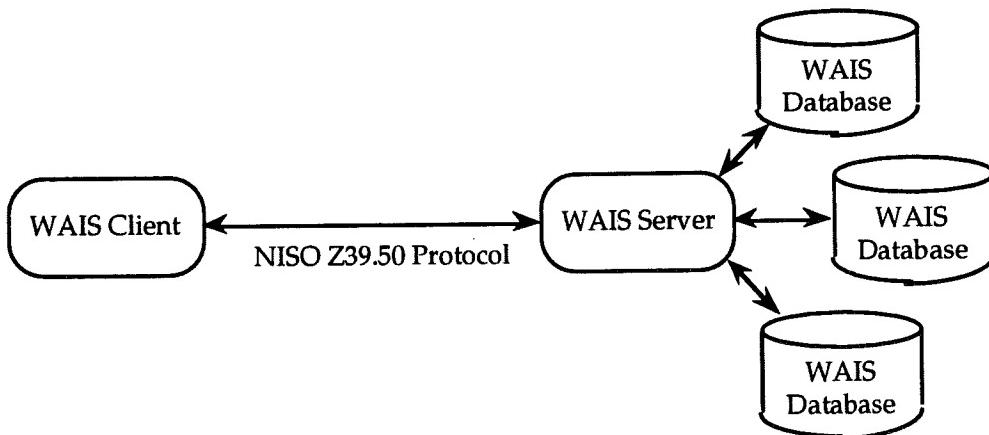


Figure 1: The WAIS Architecture

The goal of the WAIS network publishing system is to create an open architecture of information servers and clients by using a standard computer-to-computer protocol that enables clients to communicate with servers.

The WAIS client-server architecture has many advantages:

#### **Scalability**

Its distributed nature allows anyone to set up their own server and become a network publisher. The system can handle thousands of information sources on internets that span the globe, all searchable using standard software.

#### **Efficiency**

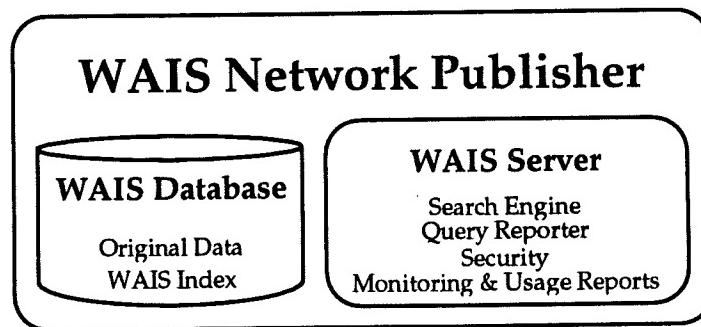
Current personal computers are high-powered and responsive to the user, and server machines have increased storage capacity and the ability to simultaneously service many users. The client-server architecture lets the client machine interact with the user as a native application on its platform. For example, a WAIS client for Microsoft Windows is a true Windows application and behaves as Windows users expect. Contrast this with most online services where a remote server controls what the user sees. The WAIS server, on the other hand, receives its questions in a standard format from all clients and can handle requests without having to recode the response for individual client programs.

#### **Global Communication**

The distances involved in global client-server applications often equate to a minimum delay of about one second. Dialup, low-speed lease lines, and wireless connections are typically the most cost-effective means users have to connect to wide-area networks. If information is transmitted on a character-by-character basis over a slow link, the delay between each keystroke could be intolerable. A client-server system can hide much of this delay by packaging up a significant parcel before sending it from the client to the server.

## **What is a WAIS Network Publisher?**

A WAIS network publisher is an information provider that supplies both a WAIS database and a WAIS server, as shown in Figure 2.



*Figure 2: The WAIS Network Publisher*

A WAIS database is made up of the publisher's original data collection and a WAIS index to facilitate fast search and retrieval of this data. The WAIS server system is composed of a search engine, a query reporter, a security system, and a monitoring and usage reporting facility. The WAIS server searches and retrieves documents from the WAIS database. Together, the

WAIS database and WAIS server make up a complete network publishing system for information providers.

Because the WAIS architecture is based on a client-server model, the information resides on the server where access can be controlled and usage can be monitored by the network publisher. As a WAIS network publisher, you have control over who has access to your data. Examples for how you might want to control access of your data include:

- Personal use only (e.g., for your personal electronic mail),
- Restricted set of users (e.g., for group or departmental projects),
- Corporate-wide use (e.g., for company resumes and associated photos, company proposals, sales videos and literature), or
- Public use (e.g., for library bibliographies, sales catalogs, marketing literature, public legislation, bulletin boards, and news feeds).

As a network publisher, you can provide your information to each user for a fee, or you can make it freely available. Since each access to your database is monitored by the server, usage patterns are recorded and can be used for statistical analysis or for billing purposes.

## What You Need to Become a Network Publisher

It's easy to become a WAIS network publisher. All that is required are the following components:

- A collection of information that you want to publish,
- The WAIS server software,
- A UNIX machine on which the information resides,
- A TCP/IP network to connect clients to the server, and
- An Internet connection (optional).

Each of these components is described in detail below. Keep in mind that most network publishers begin with only a collection of information that they wish to make available to some audience over a computer network. The steps required to become a WAIS network publisher are straightforward, even for those with little or no UNIX experience.

### Information

Your information may consist of free-form text, images, and multi-media documents. It does not have to be organized in a structured form, as in traditional database management systems (DBMS). Furthermore, your data collection can be of any size. It may be as small as 1 megabyte, or it may be very large, up to 50 gigabytes in size.

### WAIS Server

The WAIS server software is used to create an index to facilitate fast search and retrieval of your data. It also supplies the search engine, a query reporting facility, tools for restricting access and monitoring usage, and the WAIS protocol for communicating with clients.

### UNIX Platform

The WAIS server runs on most versions of UNIX. WAIS-compatible clients are available on most platforms and operating systems (MS-DOS, MS-Windows, Macintosh, X-Windows, etc.). Since the WAIS system uses a protocol based on industry

standards, servers can communicate with WAIS-compatible clients regardless of the client's platform, operating system, or vendor.

#### TCP/IP

TCP/IP (Transmission Control Protocol/Internet Protocol) is an industry-standard protocol used to transport information between computers. For a network publisher, it gives the server the appearance of a dedicated connection to a client, and guarantees the integrity of information passed between them. The WAIS protocol is built on top of the TCP/IP protocol, and manages many higher-level functions specific to information publishers and users.

#### Internet

The Internet is an international computer network used by educational, commercial, military, and government organizations. It is based on the TCP/IP network protocol. To date, the Internet services several million users in dozens of countries, and is growing in geometric proportions. The Internet provides a very wide and broad audience for network publishers. An Internet connection is optional. If you wish to publish your information only to networked clients internal to your organization, you do not need Internet access. Most publishers begin by serving their information internally, and later move to external publication over the Internet.

## Example Uses of WAIS

There are hundreds of publicly registered WAIS databases on the Internet. WAIS is used extensively within enterprises and by individuals to provide quick and easy access to information. Here are some examples of how WAIS has been put to use:

#### Formatted Files

WAIS provides a method for finding and retrieving formatted documents, whether they be phone listings, repair manuals, contracts, status reports, or marketing materials. The text contained in these documents are indexed, while the documents themselves remain unchanged.

#### Multi-Media

Multi-media documents can be included in a WAIS database by associating a text document with one or more multi-media documents. The text document generally contains textual information about the multi-media documents, and is used in building the WAIS index. When a retrieval is performed, the user has the option of displaying the multi-media documents or the text file associated with them.

#### DBMS Integration

Some organizations have existing data repositories with processes already in place for collecting, manipulating, backing up and reporting. A WAIS server can be integrated to enable users to quickly retrieve individual records from the DBMS using natural language questions. The actual data remains within the record structure of the DBMS.

#### Library System

The online public access (OPAC) portion of a library system need not be limited to use by only those trained in a proprietary client-server system. Integrating WAIS technology for public access allows patrons to remotely access MARC records as well as retrieve bibliographic material, citations, or full-text articles and even fully-formatted publications. The WAIS logging and reporting facilities provide a method of integration into circulation control and other library system modules.

**Mail Archives**

WAIS provides a robust environment with which to search through personal or group electronic mail archives. During a search, WAIS returns the subject line of the mail messages most relevant to the user's question, and then extracts the appropriate mail message when the user performs a retrieval.

## WAIS Inc

WAIS Inc promotes interoperable WAIS client-server systems. WAIS-compatible systems achieve interoperability by conforming to open national and international standards. As standards change with technological advances, WAIS Inc maintains continued conformance to these changing standards. WAIS Inc actively encourages the development and use of WAIS-related products and services by commercial, government, military, and research institutions.

WAIS Inc offers WAIS-related products and services. This section briefly describes the products and services offered by WAIS Inc.

### WAIS Inc Products

The WAIS Inc product line provides server software for WAIS-compatible clients. The products include the WAIS Server™ and the WAIS Workstation™ servers, and the WAIS Forwarder™:

**WAIS Server**

The WAIS Server product is designed for the commercial network publisher whose data collections total over 100 megabytes.

**WAIS Workstation**

The WAIS Workstation product is designed for enterprise-information sharing and smaller network publishers. This configuration is limited to databases of 100 megabytes or less<sup>1</sup>.

**WAIS Forwarder**

The WAIS Forwarder product provides access to WAIS servers from within a secure network. The WAIS Forwarder is appropriate for secure sites connected to an external network, such as the Internet, through a firewall machine.

The WAIS Server, WAIS Workstation, and WAIS Forwarder products are available on most popular UNIX platforms.

### WAIS Inc Services

WAIS Inc provides a variety of optional customer services. These include installation and training, product trial evaluations, support and maintenance agreements, and alliance support and development programs.

**Installation and Training**

WAIS Inc provides on-site start-up support and system administrator training.

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<sup>1</sup>Actual size limit is based on the WAIS index size, which can be up to 40 megabytes. This index will serve approximately 100 megabytes of text, or larger graphic-oriented databases.

**Evaluation Trial**

A two-month trial evaluation period is arranged where a WAIS server is set up at the customer's site, or the customer's data is mounted at a WAIS Inc facility.

**Custom Database Integration**

WAIS Inc provides custom integration to a customer's database management system. The custom integration permits a WAIS server to index and retrieve documents directly from the database management system. Custom parser development is also available. WAIS Inc provides a free evaluation of a customer's database integration needs, and can recommend an integration strategy.

**Support and Maintenance Agreement**

Customers receive updates, bug fixes, technical support, and training information from WAIS Inc on an on-going basis.

**Alliance Support and Development Program**

WAIS Inc or their licensed representatives provide dedicated personnel for on-going administration, support, development and customization of WAIS Inc servers.

## Overview

The remainder of the *WAIS Server and WAIS Workstation Technical Description* presents the technical details of the WAIS Server and Workstation products from WAIS Inc. The sections include:

**Chapter 2 The WAIS Database**

Defines what a WAIS database is, and how the parser and the indexer programs are used to create a WAIS database. It describes the input file formats of the parser, the parser's output, and the steps required to create a new parser. It also details the components of the indexer, how an index is used in a search operation, and many additional features of the indexer.

**Chapter 3 The WAIS Server:**

Describes the operation of the server, the search engine, the query reporter, the security system, and the monitoring and usage report facilities. It also describes the server extension capability using external filters.

**Chapter 4 The WAIS Protocol Suite**

Describes the WAIS protocol suite as based on both nationally and internationally-accepted standards. It also explains the characteristics and components of the WAIS protocol.

**Chapter 5 The WAIS Forwarder**

Explains the operation and features of the WAIS Forwarder product.

**Appendix A Glossary of WAIS Terms**

Contains a dictionary of all WAIS-related terms and definitions.

**Appendix B WAIS References**

Includes a listing of WAIS Inc literature, WAIS-related articles, publications and videotapes, electronic services, and WAIS freeware information, Z39.50 publications, and Internet information.

## 2

# The WAIS Database

## What is a WAIS Database?

A WAIS database is made up of two components: a collection of information, and a WAIS index of this collection. The collection of information is generally referred to as the original data, or just data. It is supplied by you, the network publisher. The WAIS index is a set of files generated by the WAIS programs. It facilitates fast search and retrieval of the information stored in the database. Taken together, the original data and the WAIS index are the essential ingredients making up a complete WAIS database system.

The original data is made up of a set of documents, headlines, and words. A document is the smallest retrievable element of the data collection. For example, a data collection may contain a volume of journals, where each article of the journal is a separate document. Another example is electronic mail, where each mail message is a different document. Each document may be represented in several formats: text, image, or video, or a combination thereof. In a data collection of commercial product catalogs, for instance, each document may contain a textual description of the product, a picture, and possibly a short sales video.

Each document contains a headline. The headline is used to convey the main idea behind the document. When a client sends a question to a server, the server responds with a list of headlines that represent the most relevant documents related to the client's question. Generally, each headline is automatically extracted for you from your original data collection.

In addition to a headline, each document has associated words. These words constitute the text of the document. Together, the headline and the words are used to determine how relevant a document is to a client's question.

A WAIS database is constructed by using the WAIS parser and WAIS indexer programs to create a WAIS index. The parser reads the original data and separates it into documents, headlines, and words. The indexer takes the information generated by the parser and creates the WAIS index.

## The Parser

The WAIS parser is a program that separates a collection of documents into components consisting of a headline, field information, and words. The WAIS parser is actually made up of a large number of parsers for handling many different kinds of document formats.

The WAIS parser was intentionally designed to be a program distinct from the WAIS indexer program. Separating the WAIS parser from the WAIS indexer creates a more modular and maintainable environment for incrementally developing new parsers without any need to modify the WAIS indexer. Adding a new parser is as easy as defining a small number of new functions.

This section details the input file formats for the parser, the format of the WAIS parser output, and the steps required to add a new parser.

## Parser Input

The input to the WAIS parser is a set of documents making up your original data collection. The data can consist of collections of text, audio, and visual documents in many different file formats. Additionally, the data may be structured in a wide variety of ways. For example, the data may be organized in a single file, across multiple files, or as multiple files in different directory trees. The WAIS parser reformats the data and outputs a single common format acceptable to the WAIS indexer.

The WAIS parser needs to know three items: what documents need to be parsed, how the parser should read these documents, and how the client should display these documents. Each of these is described in more detail below.

### Document Specification

The documents in your data collection are specified by filename. If multiple files are specified, the WAIS parser parses each file, one at a time, in the order they are listed. If a directory is specified, all files in that directory are parsed in alphabetical order by filename. With a special option to the parser, the parser can also recursively traverse each directory tree in a depth-first manner.

### Parse Formats

When the WAIS parser encounters a new file, it must know how to read the information contained in the file. For example, it needs to know if the file contains a single document, or a set of documents. The parser must also be able to distinguish the headline, the field information, and the words of the text. Generally, most files use one of the following parse formats supported by WAIS Inc:

#### **dash**

The dash parse format is useful if a single file contains multiple distinct documents. In the dash format, each document is separated by a row containing a minimum of 20 dash characters, "-". The line following the dashed line is expected to contain a headline, followed by the text of the document.

#### **dvi**

The dvi parse format is for Device Independent Printer Output files. The filename is used for the headline, and the contents of the file supply the words of the document.

#### **filename**

The filename parse format treats each file as a single document, and uses the filename as the headline. The contents of the file however are generally not parsed. This format is useful for data collections made up of many individual binary files, for example, whose contents are not words.

#### **first-line**

The first-line parse format specifies that each file contains a single document, and that the first non-blank line of the file is the headline, and the remainder of the file is parsed as words.

#### **first-words**

The first-words parse format is similar to first-line, except that the headline is the first 100 non-whitespace characters in the file.

**gif**

The gif parse format is for CompuServe's popular Graphics Interchange Format files. The file is considered to be a single document where the filename is used as the headline, and there are no words in the document. Image files, such as gif, can be associated with a descriptive text file and considered as a single document by the WAIS parser, indexer, and server.

**mail-digest**

The mail-digest parse format is for standard Internet mail digest files. A mail-digest file contains one or more electronic mail messages, in which each mail message is parsed as a separate document. The subject line of the mail message is the headline, and the body of the message contains the words of the document.

**mail-or-rmail**

The mail-or-rmail parse format is used for UNIX mail files. A mail file is a single file containing one or more electronic mail messages, where each mail message is parsed as a separate document. The subject line of the mail message is the headline, and the body of the message contains the words of the document. In addition, the sender, the receiver, and the date are recognized as field information.

**netnews**

The netnews parse format is used for Internet Network News, where each Network News or Read News file contains one or more news messages. Each news message is parsed as a document, where the subject line is the headline, and the body of the message contains the words of the document.

**one-line**

The one-line parse format is a simple format that treats each line of a file as a separate document. The line also forms the headline for that document.

**paragraph**

Like the dash format, the paragraph parse format is useful if a single file contains multiple distinct documents, or paragraphs. In the paragraph format, each paragraph is separated by one or more blank lines. The first line of each paragraph is the headline which is followed by the text of the document.

**pict**

The pict parse format is for Apple PICT image files. The file is considered to be a single document where the filename is used as the headline, and there are no words in the document. Image files, such as pict, can be associated with a text file and considered as a single document by the WAIS parser, indexer, and server.

**ps**

The ps parse format is for PostScript files. The filename is used for the headline, and the contents of the file supply the words of the document.

**source**

The source file format is a file format generated by the WAIS indexer for the Directory of Servers. The file typically contains information about the database, and is parsed exactly like the text file format.

**text**

In text format, each file is treated as a single document, the filename is used as the headline, and the contents of the file are parsed as words. This format is useful for data collections made up of many individual files. This is the default parse format.

**tiff**

The tiff parse format is for tagged interchange file formats. The file is considered to be a single document where the filename is used as the headline, and there are no words in the document. Image files, such tiff, can be associated with a descriptive text file and considered as a single document by the WAIS parser, indexer, and server.

**Display Formats**

The display format determines how a client should display a retrieved document. In many cases, the document is a simple text file, and thus has no special display needs. In other cases, the document may be in a specific format that should be displayed with a special display program. For example, suppose a document was generated using Microsoft Word. The client that retrieves this document must be told that the document is in Microsoft Word format in order to display it correctly. To do this, a display format of **MS-WORD** is given to the parser.

The parser associates a display format with each document. The parser passes the display format through to the indexer, which in turn stores it for later use by the server. When a client requests a search, the server responds by sending the client a list of matching documents. For each document, the server sends back a headline, document identifier, and a list of available display types for that document. It is up to the client to decide whether or not it can display this format, and to specify its preferred display type when it retrieves the document.

Examples of typical display formats supported on many existing WAIS clients are listed in Table 1.

Display Format	Description of Format
DVI	Device-Independent Printer Output
GIF	Graphics Interchange Format
	CompuServe Images
MIME	AT&T Multimedia Document
MS-EXCEL	Microsoft Excel Spreadsheet
MS-POWERPOINT	Microsoft PowerPoint Slides
MS-WORD	Microsoft Word Document
PERSUASION	Aldus Persuasion
PICT	Apple PICT Image
PS	PostScript
QUICKTIME	Apple Quicktime Movie
TEXT	ASCII Text
TEXT-FTP	Special FTP File Format
TIFF	Tagged Interchange File Format
	A Universal Raster Image Format
WQST	WAIS Question Format
WSRC	WAIS Source Format

*Table 1: Display Formats*

The exact name of the display format you select depends on the display format supported by the WAIS clients that will be accessing your database. For this reason, you may want to check your client software to determine what display formats it supports.

**Parser Output**

The output of the WAIS parser is a formatted stream that can be piped directly into the WAIS indexer. The basic entity output by the parser is the document. For each document, the parser

outputs specific document information, the headline, file information, field information, a date, and the words of the document.

#### **Document Information**

For each document, the parser outputs document information containing the location of the document relative to other documents in the data collection, and the names of the file or files that make up the document.

The location of each document is recorded by the parser as follows. Each document encountered by the parser is assigned a unique document identification number, or doc-num. The parser also records the doc-num of the containing or parent document. These identifying numbers are used to determine if the document is a piece of some larger document, such as a section of an article, or a chapter in a book. If the doc-num of a document is the same as the doc-num of its parent document, the document is a stand-alone document. Additionally, the parser records whether or not a document is in an ordered series of documents. Taken together, the doc-num, the parent doc-num, and the sequential document ordering provide the capability for systematically browsing through documents in a database.

As part of the document information, the parser also extracts and records the name of the file or files that make up the document. There may be one primary file containing the text of the document and several secondary files that contain audio or visual information.

#### **Headline**

Each document contains a headline, a string of one or more words specifying the main theme of the document. The headline is used for subsequent indexing, searching, and retrieval. The parse format determines how the parser should extract headlines. For example, if the parse format is specified to be "first-line", the parser extracts the headline from the non-blank line of the file.

#### **File Information**

Each document is extracted from one or more files. For each file associated with a document, the parser records information about the file. This information includes the date the file was created, the date the file was last modified, the display format of the file, and the location in the file where the document begins.

#### **Date**

The parser extracts a date for each document in the data collection. A date consists of a year, month, day, hour, minute, and second component. If a document is made up of several files, the parser records the date of the most important file.

#### **Field Information**

A field is a subsection document. For example, a document could have an "author" field whose value is the name of the document's author. In WAIS, fields allow a user to restrict a search to a subsection of a document. A user may wish to restrict a search to only those electronic mail documents whose subject line is "Generic Record Syntax" and whose sender is "John", for instance.

A WAIS database may contain up to 254 fields. Each field may be identified by several names. In electronic mail documents, for example, the "sender" and the "from" fields are different names for the same field. The parser must be able to recognize the start of each field, and parse its associated value. The parser then sends this information to the output stream for further processing by the indexer.

**Words**

If a document consists of text, each word in the text is extracted by the parser. The parser outputs each word, the weight of the word, and the location of the word in the file.

## Developing A New Parser

When a new file format is encountered, one of two strategies may be used to parse the new format. If possible, the data may be converted to one of the existing WAIS parse formats. When conversion is not a possibility, a new parser can be developed to handle the new format. WAIS Inc offers two solutions. First, WAIS Inc offers a custom parser toolkit to help you implement your own parser. And second, WAIS Inc also offers services to develop and maintain specialized parsers to meet the needs of individual publishers.

Due to the modularity of the WAIS parser, developing a new parser is quick and easy. The development involves the addition several new functions, and the addition of a new `defParser` data structure.

**Document Separator Function**

A Document Separator Function is required if a file consists of multiple documents. The function tells the parser when it encounters the boundary between documents. In the case of the dash format, for example, the function returns a true value to the parser when it encounters a line of dash characters, and a false value otherwise. If the file contains a single document only, the function is not required.

**Field Function**

A Field Function may be desired if one or more fields need to be recognized by the parser. For example, in a collection of electronic mail messages, each message may contain a "From" or "To" field. The Field Function detects when a line contains a field name, and outputs the field name, its associated field identifier (1-254), and a short description of the field.

**Gather and Finish Headline Functions**

The Gather Headline Function is called on each line of the document, and extracts headline terms from that line. When the end of the document is reached, the Finish Headline Function is called to do any final processing of the headline and return the headline to the parser.

**Date Function**

The Date Function is required if the date appears in each document in a special format. The Date Function parses the special format and sends the date information back to the parser.

**Gather and Finish Document Key Functions**

The Gather and Finish Document Key Functions are used in advanced parsers designed to store documents in a DBMS instead of a file system. The Gather Document Key Function is called on each line of the document, and examines the line to determine if it contains a special document key. When the end of the document is reached, the Finish Document Key Function is called to return any document key that was found during parsing.

**Assoc Function**

The Assoc Function is called on each line of the document to determine if the document should be associated with any other related documents. If so, it builds an association record containing the related documents.

**defParser Data Structure**

The defParser data structure tells the parser about the new parse format. It also supplies of list of the functions to run when parsing a document of the new format. These functions include the Document Separator Function, the Field Function, the Gather and Finish Headline Functions, the Date Function, the Gather and Finish Document Key Functions, and the Assoc Function. The data structure also supplies a string for the name of the parser, a short description of the parser, whether or not to parse and index the contents of the file, and the default display type associated with the parser.

## The Indexer

The WAIS indexer takes the information generated by the WAIS parser, and formats it for efficient search. The WAIS index's overhead is small, typically one-third to one-half the size of the original data.

This section describes the various components of the WAIS index and explains how the server uses the index during a search operation. It also covers some of the additional features of the indexer, including incremental indexing, customizable stopwords, stemming, and thesaurus lookup.

### Components of a WAIS Index

The WAIS indexer creates a WAIS index, which is made up of the following components:

**Dictionary**

The dictionary contains a sorted list of all the words used in the data collection. Each word points to a corresponding entry in the inverted file.

**Inverted File**

For each word listed in the dictionary, the inverted file lists all the documents containing that word. Each document listed contains a pointer to a corresponding entry in the document table.

**Document Table**

The document table contains a record of each document in the data collection.

**Headline Table**

The headline table contains the headlines of all the documents in the data collection.

**Filename Table**

The filename table contains a list of the filenames in the data collection.

These files are automatically generated by the WAIS indexer and are sequentially referenced by the WAIS server during a search request. For efficiency, they are stored in binary format. In addition, there are three human-readable auxiliary files used by the WAIS server:

**Catalog**

The catalog contains a human readable list of headlines and document identifiers for some or all of the documents in the database. This list may be returned to a user whose search has gone poorly, as an aid to help them understand the contents of the database. The catalog is automatically created by the WAIS indexer.

**Source Description**

The source description describes a WAIS database and its server. It is used by the client to contact the server and search its database. Typical contents are the machine name, IP

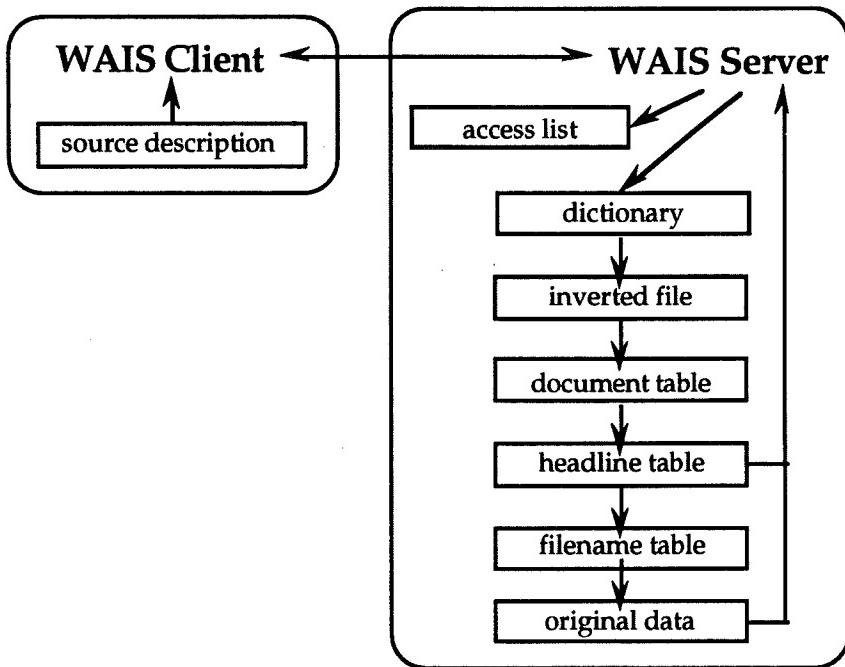
address, port of the server, the name of the database, and a short description of the database. The source description file is created by the WAIS indexer the first time the data collection is indexed, and is updated by the database administrator.

#### Access List

The access list contains the addresses of all machines which are allowed to search the database. It is an editable file created by the database administrator to control access to the database.

### How the Index is Used

The interaction between the WAIS index files is illustrated in Figure 3. A client uses a source description file to contact the server. The server checks the access list to make sure the client has permission to access this database. If so, it looks up the words in the client's question in the database's dictionary. It uses information in the dictionary to look up lists of documents in the inverted file. The document table is then consulted, which gives a pointer to the headline table, which in turn gives a pointer to the filename table. Finally, using information from the filename table, the original data file is consulted, and results are returned to the client.



*Figure 3: How the WAIS index is used during a search.*

### Incremental Indexing

The WAIS indexer also offers incremental indexing. Incremental indexing allows you to add more documents to your WAIS database without having to reindex. It indexes only those documents that are new or have changed since the last time the data was indexed. This feature is especially important for network publishers whose data changes often, and whose database size is large.

## Customizable Stopwords

A **stopword** is a frequently used word that, when encountered in a user question, is ignored. For example, since the word "the" commonly appears throughout the English language, it does not help distinguish between documents. Thus it is typically regarded as a **stopword**. The WAIS indexer includes a list of approximately 300 standard stopwords which can be specially customized for each WAIS database.

## Stemming

**Stemming** is a technique used to automatically derive variations of a queried word. These variations are then used as part of the search. If a question contains the word "skate", for example, stemming is used to find documents that may also include "skates", "skated", and "skating". Two types of stemming are supported: Plural and Porter stemming. Plural stemming attempts to determine the singular form of a word. Porter stemming<sup>2</sup> attempts to find the real base, or stem, of a word and derive any possible alternate variations. The stemming algorithm is selected by the database administrator prior to indexing the database.

## Thesaurus Lookup

The server supports thesaurus lookup to aid the user in finding synonyms for the words in a user's question. Each entry in the thesaurus contains a list of pairs, where each pair is made up of a question and a weight. The question is an expression containing a combination of natural language and boolean terms, and the weight is a measure of the importance of the pair to the other pairs on the list. The thesaurus is constructed by the database administrator after indexing, and is typically based upon the specific needs of the users.

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<sup>2</sup> Porter, M.F., "An Algorithm For Suffix Stripping," Program 14 (3), July 1980, pp. 130-137.

# 3

# The WAIS Server

## Server Operation

The WAIS server is a process that runs on a machine containing a WAIS database, and services requests posed by a client process. The server receives two types of requests from a client: a request to search and a request to retrieve. A search request invokes the WAIS search engine which returns a list of headlines matching the user's question. A retrieve request returns the requested document to the client process.

The operation of the WAIS server is very simple. First a WAIS client initiates a request to a server machine on which the WAIS database resides. Next, the server machine responds by creating a new server process to handle the client's request. And finally, when the client has completed all requests from the database, it closes the connection and the server process terminates. The server also offers a query reporting facility, security, monitoring and usage reporting, and extensions using external filters.

## The Search Engine

The WAIS search engine is at the heart of the WAIS Server and Workstation products. The WAIS search engine receives a user's question, searches its database for documents most relevant to the question, and returns a relevance-ranked list of documents back to the user. A question is regarded as an expression containing a combination of natural language, relevant documents, and boolean terms. Other key features of the WAIS search engine include relevance ranking, fielded search, and right truncation.

### Natural Language

The server can be queried using natural language questions. The server does not understand the question, rather it takes the words and phrases in the question and finds documents that have those words and phrases in them. "Tell me about portable computers." is an example of a natural language question.

### Relevance Feedback

Relevance feedback is the ability to select a document or a portion of a document and find a set of documents related to it. For example, suppose you perform a search on a news database with the natural language question "What's going on in personal computers?". Scanning the headlines returned, you see the headline, "Personal Computers in K-12", where you are interested in finding more articles related to this. You can then perform the search again using

your original question, selecting this article, or a portion of the article, for relevance feedback. The search engine then returns a new list of headlines for related articles.

In essence, relevance feedback adds more words to the original question. The server analyzes the fed-back document and determines which of the words in the document are significant in the database. In other words, which of the document's words are useful discriminators setting this document apart from the rest of the documents in the database. It then uses those words to find other documents which share these words. The significance of the document's words is less than the original question's words since the user explicitly asked for those words.

One of the primary uses of relevance feedback is to help users quickly focus their search without the need to learn complex query languages. For example, you can use natural language to return a starting list of document headlines, and then use relevance feedback to focus your search on the documents most relevant. Since a WAIS search is fast, you can interactively and iteratively refine your search using a combination of natural language questions and relevance feedback.

## Boolean Operators

The boolean operators, AND, OR, NOT, and ADJ aid in establishing logical relationships between concepts expressed in natural language. These operators are especially useful in narrowing down the search.

### AND

The AND operator is helpful in restricting a search when a particular pair of terms is known. For instance, when searching for documents on the weather in Boston, a question such as "weather AND Boston" would return only those documents that contain both the word "weather" and the word "Boston".

### OR

The OR operator is often used to join two different phrases of a Boolean search. A question such as "hurricane OR tornado" would search for all documents containing either the word "hurricane", or the word "tornado", or both. A natural language question is much like having an implicit OR between the words, except that natural language does more work to determine the relevance of words and their relationships in phrases.

### NOT

The NOT operator is used to reject any documents that contain certain words. The question "basketball NOT college" would find all documents containing the word "basketball", that also do not contain the word "college".

### ADJ

The adjacent operator, ADJ, is used to ensure that one word is followed by another in the returned document, with no other words in between. For example, "cordless ADJ telephone" returns only documents with exactly "cordless telephone" and not any documents that only contain the words "cordless" and "telephone" separately.

## Mixed Natural Language And Boolean Operators

Unique to the WAIS Inc server is the ability for users to combine natural language and boolean operators to better target their searches. For example, suppose you were looking for documents specifically on portable laptop computers that are not made by Apple. The question could then be "Tell me about portable laptop computers NOT Apple."

## Relevance Ranking

Each document is scored based on its relevance to a user's question, where the most relevant document has the highest score, or rank. A document receives a higher score if the words in the question are in the headline, or if the words appear many times, or if phrases occur as in the question. A document's score is derived using techniques such as word weighting, term weighting, proximity relationships, and word density. Note that questions made up of natural language, relevant documents, and boolean expressions are all weighted using these techniques.

### Word Weight

If a word in a document is found to match a word in the user's question, the word is assigned a weight, and this weight additively contributes to the overall score of the document. The exact weight that a word receives depends on the emphasis given to the word by the author, and on where in the document the word was found. For example, a word is weighted highest if it appears in the headline, less if the word appears in all capital letters or if the first letter of the word is capitalized, and finally, a word has the least weight if it appears only in the text. The WAIS parser determines word weights as it reads through the original data collection.

### Term Weight

Each word used in data collection is assigned a numerical value, called the term weight, based on the frequency of occurrence of that word over all documents in the data collection. Words that occur frequently are not weighted as highly as those that appear less frequently. Very common words are either ignored or diminished in the scoring. For example, since the term, "animal", may occur frequently in many of the documents in a data collection, its term weight is small compared to a term such as "hippopotamus", which may occur only a few times.

### Proximity Relationships

Proximity relationships designate that if the words in a natural language question are located close together in a document, they are given a higher weight than those found further apart. The idea behind a proximity relationship is that words found in close proximity to each other in a document more likely contain the same content as that specified in the user's question.

### Word Density

The ratio of the number of times a queried word appears in a document to the size of the document is called the word density. It is a measure of how important a queried word is to the overall content of the document. A higher word density results in a higher relevance ranking.

## Fielded Search

For data collections whose documents are structured in a semi-regular format, the regular portions of the documents can be tagged by the WAIS parser as fields. A client can then ask a WAIS server to search on only those documents containing a user-specified value of a particular field. Performing a restricted search based on the value of field or set of fields is called fielded search.

The mail-or-rmail parse format is an example of a parse format in which fields are tagged. For this parse format, the WAIS parser detects the "to" and "cc" fields, the "from" and "sender" fields, the "subject" field, and the "date" field. An example of a question using natural language, a boolean operator, and fielded search is: "company picnic AND from=barbara". The

WAIS server would then return documents containing messages about a company picnic and a "from" field containing "barbara".

## Right Truncation

A user can specify right truncation by ending a word with the asterisk ("\*") wild card character. This tells the search engine to search on words matching the base characters before the "\*" and to ignore any trailing characters. For example, you might use right truncation in a question such as "geo\*", which may retrieve documents containing the words: geographer, geography, geologist, geometry, geometrical, etc.

## Query Reporter

A query report is a document created by the server that describes how a client's question is parsed by the server. When a client asks a question of a database, the server creates and returns a query report to the client. The query report is the last document in the relevance-ranked list of documents returned by the server. The headline of the query report is listed as 'Query Report for this Search', and its relevance score is 1. Since the query report is an actual document, it may be retrieved for viewing by the client.

The query report contains the following information:

- The database being questioned,
- The original question,
- The boolean equivalent of the question in infix notation (This notation is a fully-parenthesized version of the question, showing the boolean operator precedence),
- The boolean equivalent of the question displayed as a tree,
- The number of documents and the number of words in the database,
- The number of unique words in the database,
- The number of times each word in the question occurred in the database,
- The expanded search words resulting from right truncation, and
- The number of documents found that satisfied the question, and the amount of elapsed time it took to perform the search.

The purpose of this information is to give the user feedback on how the question was interpreted by the server, and on how well the information in the database matched the words in the question. Below is an example query report generated from the following question using right truncation and the AND boolean operator: "carbon monox\* AND poison". Simply stated, the question is looking for documents on carbon monox\* and poison\*. The question uses right truncation for monox\* and poison\* to match words such as monoxide, monoximes, etc., and poisoned, poisoning, and poisonous.

```
Headline: Query Report for this Search
This is the search report for the search you ran on Aug 9 13:31:51 1993.
It is a temporary file, and will expire about an hour after the search.
```

```
-----  
Searching /wais/indexes/mydatabase...
```

```
Your query:
```

```
carbon monox* AND poison*
```

is equivalent to:

```
((carbon monox*) AND (poison*))
```

and was interpreted as:

```
AND  
( carbon monox*  
  poison*  
)
```

The database contains 39,062,401 words in 230,750 documents.  
There are 639,200 different words.

carbon occurs 30,404 times in 14,896 documents.

monox\* is expanded to:

```
monoxide occurs 3,825 times in 2,515 documents.  
monoximes occurs 1 time in 1 document.  
monoxodithioacetal occurs 1 time in 1 document.  
monoxygenases occurs 2 times in 2 documents.  
monoxyhemoglobin occurs 1 time in 1 document.
```

poison\* is expanded to:

```
poisoned occurs 61 times in 49 documents.  
poisoning occurs 486 times in 283 documents.  
poisonous occurs 17 times in 14 documents.
```

The search found 67 documents. It took about 5 seconds.

---

The search was performed by a WAIS Inc server: WAIS waisserver 1.0.  
For more information email info@wais.com.

## Security

### Access List Security

The WAIS server uses an access-list security system to limit client access to WAIS databases. Before processing a client's request, the server checks to see if the requesting client has access to the requested database. It does this by checking an access list maintained for each database. The access list tells the server the legal client machines that have access to the database. The identity of the machine is based on the machine's Internet address. The access-list security system can be used with all existing WAIS clients, and is built in to the WAIS Server and WAIS Workstation products.

### Authentication Option for the WAIS System

Kerberos is an authentication system designed by MIT for use on the Internet. MCC, the Austin-based consortium, is offering this as an add-on to WAIS Inc products for those who would like this level of user authentication. Kerberos requires special client software, but uses WAIS Inc's server technology. Kerberos offers centralized key management for database holdings.

## Encryption Option for the WAIS System

Public key authentication and encryption systems work well in the WAIS system. Encryption systems can be added to the WAIS system since the directory and architecture are compatible with the Whitfield Diffie public key system structure. With this structure, a variety of communications systems can be used without changing the encryption scheme. This facility will be built into the WAIS system based on customer demand and requires specialized client software.

## Monitoring and Usage Reports

The WAIS server automatically records all transactions in a log file. The usage characteristics of your server can be extracted from this log file and summarized in a WAIS Usage Report.

For each client process requesting service, the WAIS server records in the log file the server's process identification number, the current count of the number of transactions performed for this client, the date, the time, and the type of transaction. The WAIS server records six transaction types:

- Opening a connection,
- Searching a database,
- Returning results from a search,
- Retrieving a document,
- Closing a connection, and
- Errors and warnings.

If a search transaction is performed, the server records the name of the database and the client's question. If results were returned from a search, the number of documents found and the document identifiers are logged. And finally, if a document is retrieved, the document identification number, the database name, the document size, and the document display format are all recorded.

A WAIS Usage Report summarizes the information contained in the log file. The summary contains the following information:

### Total Number Of Connections

The total number of independent client connections made to the WAIS server. A single connection can span over multiple searches and retrievals, and over multiple databases.

### Number of Different Machines Connecting

The total number of different client machines requesting services from this WAIS server.

### Total Number of Searches

The total number of searches requested by all clients.

### Total Connect Time (seconds)

The sum of the connect time of all clients. The connect time is the lifetime of each server process, in seconds. The majority of the connect time is idle time.

### Total Search Time (seconds)

The sum of the search time of each server process, where the search time is the elapsed time, in seconds, that each server spends servicing its client's search request.

**Searches Returning Zero Hits**

The total number of search requests resulting in no matches, where the server process was unable to find any documents matching the client's question.

**Total Number of Documents Retrieved**

The total number of documents retrieved by all clients.

**Total Number of Databases Searched**

The total number of different WAIS databases that clients have searched.

**Number of Searches with no Database Name**

The total number of times clients requested a search without specifying the database name.

**Number of Searches Requesting Help**

The total number of times a client process requested a search for "?" or "help". This gives you an idea of how many new users are requesting information about the databases served on this machine.

**Average Number of Seed Words per Search**

The sum of the number of words contained in all questions divided by the number of questions, or search requests. The word count also includes boolean operators and stopwords.

**Number of Searches using Relevance Feedback**

The total number of searches performed with relevance feedback.

**Number of Server Warnings**

The number of times a warning occurred while processing a client's request.

**Number of Server Errors**

The number of times an error occurred while processing a client's request.

**Number of Search and Retrieval Requests**

The total number of search and retrieval requests for each database searched by a client process. This information gives you a quantitative idea of the load on each database provided by the WAIS server.

**List of Client Machines**

The names of all client machines accessing the server's databases and the number of connections requested by each machine.

**Client Information**

The names of the client software and the number of connections requested by clients using this software.

**Errors and Warnings**

The error and warning messages of any problems reported by the server.

## Server Extensions with External Filters

An external filter is a general means to extend the functionality of your WAIS server without requiring source-code modifications. An external filter can be used to:

- Access data stored in a remote database (e.g., access data in an external DBMS),

- Change the display format of the document (e.g., convert TIFF to GIF or convert SGML to ASCII text),
- Allow the server to cache documents that are hard to generate (e.g., cache a document from an external database, or a document converted to a different display format)
- Restrict access of a document to only specific users (e.g., by modifying the document that the user receives),
- Create documents based on dynamic data (e.g., current temperature), and
- Provide out-of-band retrieval (e.g., FAX delivery of a document to the user).

An external filter is a program run by the server when a WAIS client requests retrieval or relevance feedback of a document. The server invokes the filter with a document identifier (doc-id). The filter uses the doc-id to access and optionally modify the requested document, and sends the result back to the WAIS server. The server then either returns the result to the client, or uses it to perform relevance feedback.

Servers can be configured to run several filters. In addition, each database can define its own filters. The server decides at access time which external filter to use. Since filters are external to the server, they can be customized and maintained by the system administrator. An external filter can be implemented in any standard UNIX programming language or shell script.

# 4

# The WAIS Protocol Suite

## WAIS and Standards

The WAIS protocol suite is based on national and international standards. WAIS Inc is committed to using standards for communicating between clients and servers since this offers both technical and market-growth advantages. As different vendors offer WAIS-compatible systems for serving different markets, the protocol becomes the important piece for tying the implementations into a working whole. The WAIS protocol enables the interoperability of a global system made up of thousands of interacting pieces.

Because the WAIS protocol is based on open standards, more value can be brought to WAIS-compatible products from many companies. With companies in different fields all joining in to using the protocol, the expertise of each field is leveraged. For example, while software vendors develop and market user interfaces, publishers craft appropriate collections and presentations of information.

Several different standards all working together are needed to make a successful network publishing system since one standard would not take advantage of successful work being done on other standards. For example, WAIS is not restricted to using only one document format, since many existing document formats are in current use and are likely to change. Support for multiple standards also lessens reliance on any one proprietary standard. This prevents customers from being locked into a single vendor's proprietary system.

The WAIS protocol has been proven globally by WAIS Internet servers in 12 countries supplying over 400 databases, serving over 30,000 users in 28 countries. Given the current success of the WAIS protocol on the Internet, WAIS Inc continues to support the standards and push for the enhancements needed for the network publishing industry.

## Characteristics of the Protocol Suite

The characteristics of the WAIS protocol suite include:

### Based on Open Standards

WAIS Inc is committed to using national and international standards. The alternative to basing the system on open standards is to use proprietary standards. Where proprietary protocols may be more responsive to user needs because the authority to change them is centralized, the proprietary nature places reliance on a single company. Network publishing depends on a "critical mass" of publishers and users. Avoiding impediments in the way of creating that critical mass is essential to the long-term success of the system.

**Scalable to Large Numbers of Distributed Clients and Servers**

Internal to an organization, or across a wide-area network, the WAIS protocol is scalable to large numbers of distributed clients and servers. Finding the right server to be asking questions of is a large part of the challenge of a successful network publishing system. Users are informed about what servers are available, how to contact them, and how much they cost.

**Scalable to Small and Large Data Collections**

The size of a data collection can range from less than a megabyte to tens of gigabytes. A network publishing protocol allows searching and browsing in these environments. Hierarchical file browsing such as directories, FTP, or Gopher, do not scale to very large collections of data. Keyword searching does not extend to very small collections. A successful network publishing system incorporates both needs.

**Provides Accounting Information for Billing**

The exact billing method used in network publishing is left up to the network publisher. Pay-per-minute has been the traditional method on dialup systems, while subscriptions have been the method on most CDROM releases. Pay-per-search or pay-per-retrieval have also been tried. With a client-server system, any combination can be used since the server monitors user activity.

**Provides Access Restriction for Security and Charging**

Any user might be able to get information about a database but be restricted from searching or retrieving information from it, or in other cases no information should be known to outside users. Varying levels of security is available on a database-by-database basis to address the concerns of security and charging.

**Flexible to Adapt to the Changing Needs of a New Industry**

The WAIS protocol suite is flexible enough to accommodate the needs of a rapidly changing industry. For example, it takes into account what is known about future needs such as video, wireless networks, and penpoint systems. This means that the standards communities behind the different pieces are responsive, and there is a mechanism for introducing new standards into the suite. WAIS Inc works with both the network publishers and the standards committees to ensure an enduring environment for publishing.

## Components of the Protocol Suite

The WAIS protocol suite is made up of several pieces:

**Information Retrieval Standard Z39.50**

The WAIS protocol is based on the ANSI (American National Standards Institute) NISO (National Information Standards Organization) Z39.50 Information Retrieval Service and Protocol Standard. The national standard is a superset of the ISO (International Standards Organization) Search and Retrieve Service Definition and Protocol Specification standard (ISO 10162 and 10163).

**Document Formats**

WAIS is used to find and retrieve information in many standard document formats. For example, word processor documents can be integrated into the same system with DBMS records and news feeds. Example formats are: SGML, GIF, MARC, ASCII, Microsoft Word, Microsoft Excel spreadsheets, and CAD drawings.

**Document Identifiers**

WAIS returns a list of document identifiers (doc-ids) as the result of a search. A doc-id describes how to retrieve a document's data. This allows a user to disconnect from the server and still be able to retrieve the document at some later time. The doc-id structure also allows a document to refer to another without having to republish it. This eliminates copyright violations by always pointing back to the original source and allowing the original owner to control access to the document. WAIS doc-ids were developed as part of the WAIS system because, at the time, there was no standard. WAIS Inc is currently working with the IETF (Internet Engineering Task Force) on a new standard called the Universal Resource Locator and Universal Resource Name.

**Server Descriptions for the Directory of Servers**

To support a distributed system of WAIS servers and databases, the Directory of Servers was designed as a means of describing servers and making their databases publicly available. The Directory of Servers facility became a standardized part of the WAIS system. The Z39.50 committee is in the process of drafting a new Explain facility for servers. WAIS Inc plans to incorporate the Explain facility as soon as it becomes a stable part of the Z39.50 standard.

New pieces that are being added include:

**Authentication and Encryption**

Authentication and encryption facilities are needed in highly secure environments. Password systems, unfortunately do not scale well into a client-server environment since a user would have to remember a large number of passwords, one for each server. The Kerberos system from MIT and public-key encryption systems offer a more scalable solution for the heterogeneous network environments available today. WAIS Inc will be working on this approach.

**Billing Format Standards**

The server should feed usage information into billing systems. As standards appear in this environment WAIS Inc will pursue them. At this time, each billing system requires a different report format, and custom WAIS tools.

**Query Formats for Spatial Searching**

The US Geological Survey is pursuing standards for searching areas of the globe using latitude and longitude and returning maps. There will be other special cases for searching that will be put on top of WAIS such as DNA searching, and these will require query formats as conventions and later as standards.

**Hardcopy Delivery of Documents**

Without widespread page image standards for computers, there is a growing demand for FAX and other hardcopy delivery facilities. For example, the mechanism by which a client asks for a document to be delivered via FAX is now being actively discussed.

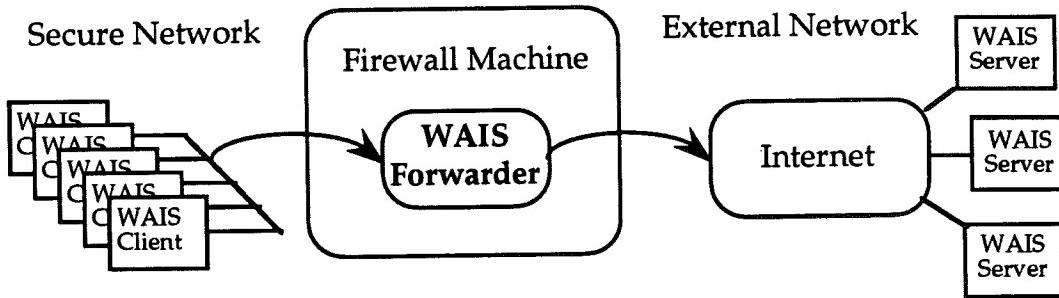
**Submitting Documents to a WAIS Database**

The number of different types of databases that would work well with WAIS would be greatly increased if it were easy to submit documents. Standards for the submission of documents to WAIS servers are being addressed.

# 5

## The WAIS Forwarder

The WAIS Forwarder product, in conjunction with a "firewall" machine, provides access to external WAIS servers from within secure environments. The WAIS Forwarder is appropriate for secure sites connected to an external network, such as the Internet, through a firewall machine.



*Figure 4: Configuration of the WAIS Forwarder*

As shown in Figure 4, a firewall is a machine that connects a secure network to an external network. Information from one network destined for the other network must pass through the firewall machine. A forwarder is a software program running on the firewall machine that permits two application programs executing on either side of the firewall to communicate with each other. The forwarder allows machines on the secure network to access the services available on machines in the external network.

In a client-server application such as WAIS, a client contacts the forwarder on the firewall machine and the forwarder contacts the outside servers. Secure machines can open connections to Internet servers transparently by sending the request to the forwarder which automatically passes the request onto the external service. External machines cannot open connections to the forwarder, thus forming a one-way security system.

The WAIS Forwarder provides a secure network with all the benefits of the Internet WAIS servers without opening the secure network to external traffic. All WAIS functions are supported through the forwarder including the Directory of Servers, searching, and retrieval of text, images, and other formats. Because the WAIS Forwarder also forwards the IP address of the requesting client machine, databases using WAIS Inc servers will continue to provide access-list security. In addition, the WAIS Forwarder optionally logs transaction statistics, enabling the firewall maintainer to monitor usage patterns.

The WAIS Forwarder is a software-only product that runs on many popular UNIX platforms and is easily configured and administered. In addition, the WAIS Forwarder works with all existing client software. For those that have special needs or security considerations, the product is available in source code as well as in executable form. The WAIS Forwarder can be purchased separately, or bundled with the WAIS Inc server products. As new versions of the

WAIS protocol suite come into widespread use, the package will be upgraded according to the maintenance and support agreement selected.

# Appendix A

## Glossary of WAIS Terms

### **access list**

An access list contains the IP addresses of all machines that are allowed to search a WAIS database. It is created by the database administrator to control access to a database.

### **boolean operator**

A boolean operator is a mathematical operator based on set theory. Boolean operators provide a powerful mechanism for specifying exact relationships between words in a WAIS question. Each boolean operator denotes a specific relationship between sets of words. For example, the question "dog AND cat" contains the boolean operator "AND", and specifies that only documents having both the word "dog" and the word "cat" will be retrieved. In terms of set theory, this question is the intersection between the sets defined by dog and the sets defined by cat. Other Boolean operators include OR, ADJ and NOT.

### **catalog**

A catalog is a file created by the WAIS indexer that contains a human readable list of headlines and document identifiers for some or all of the documents in a WAIS database. This list may be returned to a user whose search has gone poorly, as an aid to help them understand the contents of the database.

### **client**

In a client-server architecture, the client is the program which requests services. With WAIS, clients are user interface programs which request services from remote or local servers using the WAIS protocol.

### **dictionary**

A dictionary is a file automatically generated by the WAIS indexer. It contains a sorted list of all the words used in the WAIS database. Each word points to a corresponding entry in the inverted file.

## **Directory of Servers**

A Directory of Servers is a database that serves source descriptions of WAIS databases. It is a means of discovering new WAIS databases. The public Directory of Servers on the Internet is located at quake.think.com on port 210.

## **display format**

The display format specifies how a client will display a retrieved document. By default, the display format is determined by the parse format. See also parse format.

## **document identification number (doc-num)**

A document identification number is a unique number that identifies each document in a WAIS database. This number is generated by the WAIS parser and later used by the WAIS indexer. It is meant for internal use only by the server during a search operation.

## **document identifier (doc-id)**

A document identifier is a structure that uniquely identifies documents in WAIS databases. It is generated by the WAIS server and is typically stored with the user's question by the client.

## **document table**

A document table is a file automatically created by the WAIS indexer that contains a record of each document in a WAIS database.

## **field**

For data collections whose documents are structured in a semi-regular format, the regular portions of the documents can be tagged by the WAIS parser as fields. For example, in an electronic mail message, the "to" and "from" lines are tagged as fields.

## **fielded search**

A restricted search based on the value of a field or set of fields is called fielded search.

## **filename table**

A filename table is a file automatically generated by the WAIS indexer that contains a list of the filenames in a WAIS database.

## **headline table**

A headline table is a file automatically created by the WAIS indexer that contains the headlines of all the documents in a WAIS database.

**inverted file**

An inverted file is a file automatically created by the WAIS indexer. For each word listed in the dictionary, the inverted file lists all the documents containing that word. Each document listed contains a pointer to a corresponding entry in the document table.

**parse format**

A parse format determines how the WAIS parser breaks a data file into its component documents, and decides which words to use as a headline. See also display format.

**plural stemming**

Plural stemming is a stemming algorithm that attempts to derive the root form of a word if given a plural.

**port**

A port number specifies a service on a UNIX machine. For example, WAIS usually runs on port 210, and Telnet usually runs on port 23. Ports below 1,000 are called "well-known" ports, and you must be superuser to run a program on them.

**porter stemming**

Porter stemming is a stemming algorithm that attempts to find the base, or stem, of a word and derive any possible alternate variations.

**proximity relationship**

A proximity relationship designates that if the words in a question are located close together in a document, they are given a higher weight than those found further apart. The idea behind a proximity relationship is that words found in close proximity to each other in a document more likely contain the same content as that specified in the user's question.

**query**

See question.

**query report**

A query report is a document created by the server that describes how a client's question is parsed by the server.

**question**

A question is an expression containing a combination of natural language words and boolean operators.

## question structure

A question structure is a file format used by some client programs to store the state of a user's question so that it can be used again. It includes what databases to ask, the user's question, and any relevant documents. It may also store the last list of results.

## relevance feedback

Relevance feedback is the ability to select a document or a portion of a document and find a set of documents "similar" to the selection. In essence, relevance feedback adds more words to the original question. It uses the most important words and phrases in the relevant document in addition to the original question. The most important words and phrases are determined by the same weighting algorithms as the words in the original question. The weight of the relevant document terms is less than the original question terms.

## relevance ranking

Relevance ranking is the scoring of documents based on their relevance to a user's question, where the most relevant document has the highest score, or rank. A document receives a higher score if the words in the question are in the headline, or if the words appear many times, or if the phrases occur exactly as in the question. A document's score is derived from using techniques such as word weighting, term weighting, proximity relationships, and word density.

## right truncation

A user can specify right truncation in a question by ending a word with the wild card character, "\*". This tells the WAIS server to search on words matching the base characters before the \*. An example of using right truncation is a question such as "geo\*", which may retrieve documents containing the words: geographer, geography, geologist, geometry, geometrical, etc.

## server

In a client-server architecture, the server is the program which provides the services. With WAIS, a server is a machine that supports databases and answers questions.

## source description

A source description describes a specific WAIS database and its server. It is used by the client to contact a server and search its database. Typical contents are the machine name, IP address, port of the server, and the name of the database, and a short description of the database. The source description file is created by the WAIS indexer the first time the data collection is indexed, and is updated by the database administrator.

**stemming**

Stemming is a technique used to automatically derive the root of a queried word. The root is then used to search against the roots of the words contained in a database. If a question contains the word "skate", for example, stemming is used to find documents that may also include "skates", "skated" and "skating".

**stopword**

A **stopword** is a frequently used word that, when encountered in a user question, is ignored. Since it is not useful for searching, it is not indexed. For example, since the word "the" commonly appears throughout the English language, it is typically regarded as a **stopword**.

**TCP/IP**

TCP/IP is an acronym for Transmission Control Protocol/Internet Protocol. This is the low-level protocol which is used on the Internet, and on many local-area networks. It provides reliable data communication.

**term weight**

Each word used in data collection is assigned a numerical value, called the **term weight**, based on the frequency of occurrence of that word over all documents in the data collection. Words that occur frequently are not weighted as highly as those that appear less frequently. Very common words are either ignored or diminished in the scoring. For example, since the term, "animal", may occur frequently in many of the documents in a data collection, its term weight is small compared to a term such as "hippopotamus", which may occur only a few times.

**WAIS**

WAIS is an acronym for Wide Area Information Servers and a trademark of WAIS Inc.

**WAIS database**

A WAIS database consists of a set of documents and a set of index files.

**WAIS index**

A WAIS index is created by the WAIS indexer and is used to facilitate fast search and retrieval of documents in a data collection. It contains a source description, dictionary, access list, inverted file, document table, headline table, and filename table.

**WAIS indexer**

The WAIS indexer is a program that takes the documents, headlines, field information, and words generated by the WAIS parser and builds a WAIS index.

## WAIS parser

The WAIS parser is a program that reads a data file and breaks it into its component documents, headlines, field information, and words. The output of the WAIS parser is typically fed to the WAIS indexer.

## WAIS protocol

The WAIS protocol is used to connect WAIS clients and servers. It is based on the Z39.50 protocol. Because a standard protocol is used, clients and servers can be built on a wide variety of computer architectures, communicating over local and wide-area networks.

## WAIS search engine

The WAIS search engine is a component program of the WAIS server. It is responsible for answering search and retrieval requests from clients. It uses the WAIS index to find documents in the original data collection.

## WAIS server

The WAIS server is a program waits for a connection from a client, and handles the connection by searching and/or retrieving documents from a WAIS database. The WAIS server is made up of a search engine, a query reporting facility, a security system, a monitoring and usage reporting system, and an extended services facility.

## word density

The ratio of the number of times a queried word appears in a document to the size of the document is called the word density. It is a measure of how important a queried word is to the overall content of the document. A higher word density results in a higher relevance ranking.

## word weight

If a word in a document is found to match a word in the user's question, the word is assigned a word weight, and this weight additively contributes to the overall score of the document. The exact weight that a word receives depends on the emphasis given to the word by the author, and on where in the document the word was found. For example, a word is weighted highest if it appears in the headline, less if the word appears in all capital letters or if the first letter of the word is capitalized, and finally, a word has the least weight if it appears only in the text. The WAIS parser determines word weights as it reads through the original data collection.

## Z39.50

Z39.50 is the National Information Standards Organization (NISO) protocol for information search and retrieval. It is a standard used in the WAIS protocol.

# Appendix B

# WAIS References

Hard copies of most of the following documents are available from WAIS Inc. Some documents are available electronically, as stated, but may not contain figures in the ASCII version. Email, FAX, mail, or phone your name, address, email and phone number to: WAIS Inc, 1040 Noel Drive, Menlo Park, CA, 94025, phone: 415-327-WAIS, FAX: 415-327-6513, email: info@wais.com

## WAIS Inc Literature

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*WAIS Bibliography*, WAIS Inc, August 1993. (This list). Available via anonymous ftp: /pub/wais-inc-doc/bibliography.txt@ftp.wais.com.

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## WAIS Articles and Publications

*Pointing Finger, WAIS at Internet Addresses*, MacWeek, Jeff Ubois, May 28, 1993, pp 42, 44.

*WAIS Offers Publishing Products*, Open Systems Today, Paul Kapustka, May 10, 1993, pp 13.

*Unix Servers Distribute On-line Information*, Info World, Cheryl Gerber, May 3, 1993, pp 6.

*Info Access Plan Promises Power to Fed Users*, Federal Computer Week, Jennifer Jones, March 29, 1993, pp 1, 41.

*A Web of Networks, an Abundance of Services*, New York Times, John Markoff, February 28, 1993.

*Good-bye, Dewey Decimals*, Forbes Magazine, David Churbuck, February 15, 1993, pp 204-205.

*Internet Retrieval Tools Go on Market*, Network World, Ellen Messmer, February 15, 1993, pp 29, 77.

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*An Analysis of the Effects of Data Corruption on Text Retrieval Performance*, S. Smith, C. Stanfill, December 1988. Thinking Machines Corporation Technical Report TMC-68.

## WAIS Videos

*Special Interest Group on Wide Area Information Servers: Conference Held March 19, 1993*, Open-File Report 93-252, USGS video on WAIS, VHS videotape \$20. Send orders to Book and Open-File Report Sales, USGS, Federal Center, Box 25286, MS 306, Denver, Colorado, 80225.

*Wide Area Information Servers Class: Indexer and Server*, Open-File Report 93-253, USGS training video on WAIS, VHS videotape, 2-tape set \$40. Send orders to Book and Open-File Report Sales, USGS, Federal Center, Box 25286, MS 306, Denver, Colorado, 80225.

*Macintosh Demonstration Screen-Movie*, Steve Cisler put together a short screen-recorder movie of WAIStation. Available via anonymous ftp: /pub/wais-doc/WAIStation-Canned-Demo.sit.hqx@ftp.wais.com.

## Electronic Services

*wais-discussion@think.com*: Biweekly digest of mail from users and developers on Electronic Publishing. If you have WAIS-related news please send electronic mail to wais-discussion@wais.com. Send requests for inclusion on the mailing list to wais-discussion-request@think.com. Anonymous ftp access to archives: /pub/mail-archives/wais-discussion/issue-\*@ftp.wais.com. Archives are available on the public WAIS database: wais-discussion-archives.src.

*wais-talk@think.com*: An interactive list of developers that generates a couple messages a day. Send requests to wais-talk-request@think.com. Archives are available on the public WAIS database: wais-talk-archives.src.

*comp.infosystems.wais*: A netnews discussion group on WAIS issues. All postings to wais-discussion@think.com go to this group as well.

*Z3950iw*: Z39.50 implementors list for low-level discussions of protocol details. Send requests to listserv@nervm.nerdc.ufl.edu.

## WAIS Freeware Information

For information on WAIS freeware or the Clearinghouse of Networked Information Discovery and Retrieval (CNIDR), contact Jane Smith at jane.smith@cnidr.org or 919-248-9213. The director of the freeware is George Brett at ghb@jazz.concert.net or 919-962-1000.

## WAIS Freeware Servers

Server	FTP Location
NeXT	/pub/freeware/next/*@ftp.wais.com
RS6000	/pub/freeware/rs6000/*@ftp.wais.com
SGI	/pub/freeware/sgi/*@ftp.wais.com
Source Code	/pub/freeware/unix-src/wais-8*.tar.Z@ftp.wais.com
SUN	/pub/freeware/sun/*@ftp.wais.com

## WAIS Freeware Clients

Client	Author	FTP Location
DOS	Jim Fullton, UNC	/pub/wais/DOS/*@sunsite.unc.edu, or /pub/tcpip/pcwais.zip@hilbert.wharton.upenn.edu
GWAIS (Gnu Emacs)	Jonathon Goldman Thinking Machines Corp.	/pub/freeware/unix-src/wais-8*.tar.Z@ftp.wais.com
IBM Mainframe	Tim Gauslin, USGS	/pub/freeware/ibm-mvs/*@ftp.wais.com
Mac	Harry Morris, WAIS Inc Francois Schiettecatte	/pub/freeware/mac/wais-for-mac*@ftp.wais.com /pub/freeware/mac/WAISBrowser*@ftp.wais.com
Mac HyperCard	Francois Schiettecatte	/pub/freeware/mac/HyperWais*@ftp.wais.com /pub/freeware/mac/JFIFBrowser*@ftp.wais.com
Mail	Jonathon Goldman Thinking Machines Corp.	send message to waismail@quake.think.com, "search <source-name> {keywords}" or "retrieve DOCID" (DOCID as returned by a search)
NeXT	Paul Burchard, Univ of Utah	/pub/freeware/next/*@ftp.wais.com
Openlook	Simon Spero, UNC	/pub/freeware/open-look/*@ftp.wais.com
OS2	Kevin Oliveau, WAIS Inc Julie Mills, Library of Congress	/pub/freeware/os2/*@ftp.wais.com
SunView		/pub/wais/sunview/*@sunsite.unc.edu
SWAIS	John Curran, BBN	/pub/freeware/unix-src/wais-8*.tar.Z@ftp.wais.com
Telnet Access	(uses SWAIS)	Telnet quake.think.com, login wais, password user@host
VMS	Jim Fullton, UNC	/pub/wais/vms/*@sunsite.unc.edu
Windows	Tim Gauslin, USGS Kevin Gamiel, MCNC CNIDR	/pub/freeware/windows/wnwais*.zip@ftp.wais.com /pub/NIDR.tools/wais/pc/windows@ftp.cnidr.org
XWAIS	Jonathan Goldman Thinking Machines Corp.	/pub/freeware/unix-src/wais-8*.tar.Z@ftp.wais.com

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**Exploring the Internet: A Technical Travelogue**, Carl Malamud, Prentice Hall, 1992.

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